

Japanese Laid-Open Patent Publication No. H09-120067

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[Title of the Invention] LIGHT SOURCE APPARATUS AND APPARATUS USING THE SAME

[Abstract]

[Problem]

To obtain a light beam with high efficiency, high output, and high directionality.

[Solution]

A light source apparatus is constructed so that a light source 11 is disposed at a first focal point of an elliptic mirror 12, a first diaphragm 17 and a second conical prism 14 are disposed at a second focal point, a condensing lens that condenses and emits light that has passed the first diaphragm 17 is provided, a small spherical mirror 10 is disposed facing the elliptic mirror 12, and the diameter D_A of a circle A that is a line of intersection between a plane perpendicular to the optical axis and the surface of the elliptic mirror at the first focal point of the elliptic mirror 12 is larger than a diameter D_B of a circle B that is a line of intersection between a perpendicular plane and the surface of the spherical mirror 10.

[Claims]

[Claim 1] A light source apparatus in which a first focal point of an elliptic

mirror (12) approximately matches a center of curvature of the spherical mirror (10), a light source (11) is disposed at a position proximate thereto, a first diaphragm (17) is disposed in a position proximate to a second focal position of the elliptic mirror (12), a condensing lens (13) for condensing light that has passed the first diaphragm (17) is provided, and light that has passed the condensing lens (13) is emitted,

wherein a reflective surface of the elliptic mirror (12) and a reflective surface of the spherical mirror (10) face each other along an optical axis and the reflective surface of the elliptic mirror (12) is larger than the reflective surface of the spherical mirror (10).

[Claim 2] A light source apparatus according to Claim 1, wherein at the first focal point of the elliptic mirror (12), a diameter D_A of a circle A that is a line of intersection between a plane perpendicular to the optical axis and a surface of the elliptic mirror is larger than a diameter D_B of a circle B that is a line of intersection between a perpendicular plane and the surface of the spherical mirror (10).

[Claim 3] A light source apparatus according to either Claim 1 or Claim 2, wherein a relationship between a first focal point distance f_1 of the elliptic mirror (12) and a radius of curvature R of the spherical mirror (10) satisfies $f_1>R$.

[Claim 4] A light source apparatus according to any of Claim 1 to Claim 3, wherein a depth H of the reflective surface of the elliptic mirror (12) on the optical axis satisfies a relationship $f_1 \leqq H \leqq (f_1 + f_2) / 2$ with respect to a first focal point distance f_1 and a second focal point distance f_2, and a depth of the reflective surface of the spherical mirror (10) on the optical axis satisfies a relationship $R/2 \leqq h \leqq R$ with respect to the radius of curvature R.

[Claim 5] A light source apparatus according to any of Claim 1 to Claim 4, wherein a conical prism (14) is provided proximate to the second focal point of the elliptic mirror (12), and light that has passed the conical prism and the first diaphragm (17) is condensed by the condensing lens (13).

[Claim 6] A light source apparatus according to Claim 5, wherein the conical prism (14) is a convex conical prism where an apex angle α of the incident surface or the emission surface for light is 90 to 175° or a concave conical prism where an apex angle β is 185 to 270°.

[Claim 7] A projector-type display apparatus comprising a transmission/scattering type display element (15) on which light emitted from a light source apparatus according to any of Claim 1 to Claim 6 is incident and a projection optical system that projects light that has passed the transmission/scattering type display element (15)

onto a screen or the like.

[Claim 8] A projector-type display apparatus according to Claim 7, wherein a second condensing lens (16) and a second diaphragm (18) with an aperture at approximately a focal point position of second condensing lens (16) are disposed in the projection optical system.

[Claim 9] A lighting apparatus that uses a projector-type display apparatus according to any of Claims 6, 7, and 8.

[Detailed Description]

[0001]

[Field of the Invention]

The present invention relates to the construction of a highly efficient light source apparatus. Various types of optical apparatuses in which this light source apparatus is applied, and in particular a projector-type display apparatus that uses a transmission/scattering type display element and a lighting apparatus that uses this light source apparatus are described in detail.

[0002]

[Description of Related Art]

FIG. 12 and FIG. 13 show the invention disclosed by Japanese Laid-Open Patent Publication No. H07-134295 as a first related art. This invention is a projector-type display element in which the convergence of light from a light source is improved to make more effective use of light.

[0003]

FIG. 12 is a schematic diagram showing an arrangement of a light source 11, an elliptic mirror 12, a prism 14, and a first diaphragm 17 that compose the light source apparatus. FIG. 13 shows one application of this light source apparatus, where a projector-type display apparatus 500 is constructed by combining a first condensing lens 13A, a transmission/scattering type display element 15, a second diaphragm 18, a second condensing lens 13B, and a projection lens 19.

[0004]

The prism 14 in this projector-type display apparatus is disposed at approximately a second focal point position of the elliptic mirror 12. Also, this prism is approximately conical and exhibits rotational symmetry about the optical axis. Light emitted from the light source 11 that has been reflected and condensed by the elliptic mirror is incident on the prism, is refracted by the incident surface and the emission surface of the prism and is then emitted.

[0005]

In this invention, there is insufficient distributed light in the optical axis direction for the beam produced by condensing the light emitted from the light source using the elliptic mirror, but since light is refracted by the prism to make the distributed light more uniform, there is an increase in the beam density, so that the condensing efficiency for the light source is high and a bright display can be realized.

[0006]

Also, by providing the first diaphragm 17 at a position proximate to the second focal point of the elliptic mirror, it is possible to eradicate scattered light from the light source. That is, since the light source is not an ideal point light source but instead has

a finite light emitting length (the length of the filament or the like), light that does not reach the vicinity of the second focal point of the elliptic mirror and proceeds towards the first condensing lens 13A and light has not been reflected by the elliptic mirror and has not passed the second focal point but is directed towards the transmission/scattering type display element 15 can be eradicated so that the contrast between the light and dark parts of the projected image can be improved.

[0007]

Next, the content disclosed by Japanese Laid-Open Patent Publication No. H07-5419 is described as a second related art. This invention further improves the convergence of light from a light source to make efficient use of the light. As shown in FIG. 14, a construction is used where a spherical mirror 12b is arranged on the light emission side of the elliptic mirror 12a so that its center of curvature approximately matches the first focal point of the elliptic mirror. The spherical mirror used here has a radius of curvature R that is sufficiently large compared to a first focal point distance f_1 of the elliptic mirror, a diameter of an opening in the spherical mirror is larger than the diameter of an opening in the light emission side of the elliptic mirror, and the spherical mirror is disposed so as to cover the opening in the elliptic mirror.

[0008]

Also, in these related art examples, projector-type color display apparatuses are disclosed that use a white light source, a color splitting /combining system that uses two flat dichroic mirrors of different types, and a total of three transmission/scattering-type liquid crystal display elements for the respective wavelengths RGB in a reflective-type construction. These apparatuses are small, and have improved light usage efficiency and contrast for the projected images.

[0009]

[Problems to Be Solved]

The present invention has an object of providing a small, highly efficient, and high luminance light source apparatus that could not be produced according to the related art described above. A further object is to improve the optical characteristics of a projector-type display apparatus or the like in which the light source apparatus is combined with another optical system.

[0010]

[Means to Solve the Problems]

First, the present invention provides a light source apparatus that can provide a beam with a high luminance and uniform directivity. By combining an elliptic mirror and a spherical mirror, a small, lightweight, and low cost light source apparatus is constructed. In addition, a projector-type display apparatus and lighting apparatus with high performance are constructed by combining the light source apparatus with a transmission/scattering type display element. Fundamentally, a relatively large elliptic mirror and small spherical mirror are combined so as to face each other and the spherical mirror is provided inside the elliptic mirror.

[0011]

More specifically, the present invention is a light source apparatus in which a first focal point of an elliptic mirror 12 approximately matches a center of curvature of a spherical mirror 10, a light source 11 is disposed at a position proximate thereto, a first diaphragm 17 is disposed in a position proximate to a second focal position of the elliptic mirror 12, a condensing lens 13 for condensing light that has passed the first diaphragm 17 is provided, and light that has passed the condensing lens 13 is emitted,

wherein a reflective surface of the elliptic mirror 12 and a reflective surface of the spherical mirror 10 face each other along an optical axis and the reflective surface of the elliptic mirror 12 is larger than the reflective surface of the spherical mirror 10. This construction is referred to as the first invention. Here, the relative sizes of the reflective surfaces indicate the effective areas produced when a surface perpendicular to the optical axis is projected along the optical axis. In other words, this size is a cross-sectional surface of the elliptic mirror on a surface perpendicular to the optical axis.

[0012]

Also, for this first invention, a light source apparatus is provided where at the first focal point of the elliptic mirror 12, a diameter D_A of a circle A that is a line of intersection between a perpendicular plane of the optical axis and a surface of the elliptic mirror is larger than a diameter D_B of a circle B that is a line of intersection between a perpendicular plane and the surface of the spherical mirror 10. This construction is referred to as the second invention.

[0013]

Also for the first or second invention, a light source apparatus is provided where a relationship between a first focal point distance f_1 of the elliptic mirror 12 and a radius of curvature R of the spherical mirror 10 satisfies $f_1>R$. This construction is referred to as the third invention.

[0014]

Also for the first, second or third invention, a light source apparatus is provided where a depth H of the reflective surface of the elliptic mirror 12 on the optical axis satisfies a relationship $f_1 \leqq H \leqq (f_1+f_2) / 2$ with respect to a first focal point distance f_1

and a second focal point distance f_2, and a depth of the reflective surface of the spherical mirror 10 on the optical axis satisfies a relationship $R/2 \leqq h \leqq R$ with respect to the radius of curvature R. This construction is referred to as the fourth invention.

[0015]

Also for the first, second, or fourth invention, a light source apparatus is provided where a conical prism 14 is provided proximate to the second focal point of the elliptic mirror 12, and light that has passed the conical prism and the first diaphragm 17 is condensed by the condensing lens 13. This construction is referred to as the fifth invention.

[0016]

Also for the fifth invention, a light source apparatus is provided where the conical prism 14 is a convex conical prism where an apex angle α of the incident surface or the emission surface for light is 90 to 175° or a concave conical prism where an apex angle β is 185 to 270°. This construction is referred to as the sixth invention.

[0017]

Also provided is a projector-type display apparatus including a transmission/scattering type display element 15 on which light emitted from a light source apparatus according to any of Claim 1 to Claim 6 is incident and a projection optical system that projects light that has passed the transmission/scattering type display element 15 onto a screen or the like. This construction is referred to as the seventh invention.

[0018]

Also for the projector-type display apparatus of the seventh invention, a projector-type display apparatus is provided where a second condensing lens 16 and a

second diaphragm 18 with an aperture at approximately a focal point position of second condensing lens 16 are disposed in the projection optical system. This construction is referred to as the eighth invention.

[0019]

For the seventh or eighth invention, there is provided a projector-type display apparatus where the transmission/scattering type display element 15 includes a liquid crystal resin compound structure, where nematic liquid crystals with positive dielectric anisotropy are dispersed and held inside a resin matrix, between plates provided with electrodes, and the refractive index of the resin matrix is made to match the normal refractive index (n_0) of the liquid crystals used. This construction is referred to as the ninth invention.

[0020]

A lighting apparatus that uses the projector-type display apparatus of the seventh, eighth, or ninth invention is also provided.

[0021]

[Description of Preferred Embodiments]

The following description refers to FIG. 1. The fundamental arrangement and composition are approximately the same as the related art described above. However, the most characteristic point of the present invention is a positional relationship of a light source apparatus that has the elliptic mirror and the spherical mirror as component elements. The invention is also characterized by obtaining a powerful beam with a uniform light distribution.

[0022]

The light source apparatus according to the present invention is composed of

the light source 11, the elliptic mirror 12, a spherical mirror 10, a first diaphragm, and a condensing lens, not shown, the shape of the elliptic mirror 12 is set by the first focal point distance f_1, the second focal point distance f_2, and the depth H, and the shape of the spherical mirror 10 is set by the radius of curvature R and the depth h.

[0023]

The first focal point of the elliptic mirror 12 and the center of curvature of the spherical mirror 10 approximately match, and the light source 11 is disposed at a position proximate thereto. A first diaphragm 17 is disposed at a position proximate to the second focal point of the elliptic mirror 12. The reflective surfaces of the elliptic mirror 12 and the spherical mirror 10 face one another along the optical axis. At the first focal point of the elliptic mirror 12, a diameter D_A of a circle A that is a line of intersection between a plane perpendicular to the optical axis and the surface of the elliptic mirror is larger than a diameter D_B of a circle B that is a line of intersection between a perpendicular plane and the surface of the spherical mirror 10.

[0024]

The magnitude relationship between the first focal point distance f_1 of the elliptic mirror 12 and the radius of curvature R of the spherical mirror 10 is preferably $f_1>R$. It is also preferable for the depth H of the reflective surface of the elliptic mirror 12 on the optical axis to satisfy a relationship $f_1 \leqq H \leqq (f_1+f_2)/2$ with respect to the first focal point distance f_1 and the second focal point distance f_2, and for the depth h of the reflective surface of the spherical mirror 10 on the optical axis to satisfy a relationship $R/2 \leqq h \leqq R$ with respect to the radius of curvature R.

[0025]

It is also preferable for a conical prism 14 to be provided proximate to the

second focal point of the elliptic mirror 12 and for the light that has passed the prism and the first diaphragm 17 to be condensed by a condensing lens 13. The conical prism 14 is preferably a convex conical prism where the apex angle α of the incident surface or emission surface for the light is 90 to 175° or a concave conical prism where the apex angle β is 185 to 270°.

[0026]

The spherical mirror 10 is formed of heat-resistant glass molded in a hemispherical shape, and is achieved by coating its inner surface with a cold mirror that reflects visible light but transmits infra-red light and is formed by alternately laminating a film of metal with a high reflectivity for visible light, such as aluminum, or photorefractive dielectric TiO_2, and low refractivity dielectric SiO_2. It is also possible to machine a metal plate in a hemispherical shape and to coat the inner surface of this metal plate with a metal film with high reflectivity for visible light. In this case, the surface precision of the surface is inferior compared to glass, but the construction is cheap and has superior heat resistance.

[0027]

The light source has a double-layer tube construction where the entire glass bulb that forms the light emitting part is covered with a spherical glass bulb, and part of this spherical glass bulb may be coated with a reflective coating. By using this kind of double-layer tube construction, the temperature of the light emitting part is stabilized, which is advantageous in stabilizing the characteristics and extending the life of the light source.

[0028]

[Action]

According to the present invention, out of the light emitted from the light source 11, the light reflected by the spherical mirror 10 is returned to the light emitting part side and is also reflected by the elliptic mirror 12 and is condensed towards the second focal point of the elliptic mirror, so that as a result, the light distribution angle is narrowed and the beam density is increased.

[0029]

In addition, light is refracted by the conical prism 14 disposed at the second focal point position of the elliptic mirror and then emitted, which further improves the beam density and increases the light usage efficiency. This action has already been confirmed for a compound mirror where the elliptic mirror 12 and the large spherical mirror 20 shown in FIG. 14 are combined, although the external diameter of the spherical mirror 20 of the related art is larger than the external diameter of the elliptic mirror 12. With a construction according to the present invention that uses the small spherical mirror 10, the volume of the light source apparatus can be reduced, which is effective in lowering cost and in lowering weight.

[0030]

In addition, the conical prism 14 that is convex or concave is disposed at the second focal point position of the elliptic mirror 12. To prevent light that has not reached the effective surface of the conical prism from reaching the condensing lens 13, it is preferable to set a first diaphragm 17 with an aperture corresponding to the effective surface of the conical prism before or after the conical prism.

[0031]

In reality, a holder that holds the conical prism 14 functions as this diaphragm. It is preferable for the diaphragm 17 to have an aperture with a suitable shape, such as a

circle, a square, an ellipse, or a rectangle, for the optical shape of the transmission/scattering type display element 15.

[0032]

By doing so, light components that propagate from the light source 11 with a finite length, the spherical mirror 10, and the elliptic mirror 12 but are not condensed near the second focal point position are removed, so that a tight beam can be formed and when the transmission/scattering type display element 15 is in a scattering state, there is a reduction in the amount of extraneous light that reaches the screen, so that the contrast can be improved.

[0033]

In particular, this effect is especially large if a means for removing scattered light, and more specifically a second diaphragm 18, is provided between the transmission/scattering type display element 15 and the screen. Unevenness in the light intensity distribution across the screen of the transmission/scattering type display element 15 due to insufficient light components at small angles to the optical axis at the second focal point position caused by use of the compound mirror composed of the spherical mirror 10 and the elliptic mirror 12 is greatly improved and the intensity distribution is made uniform by using a convex conical prism where the apex angle α is 90 to 175° or a concave conical prism where the apex angle β is 185 to 270° according to the shapes of the light source and the compound mirror.

[0034]

In view of the usage efficiency of light and the luminance distribution on the projector screen, a range of 100 to 140° for the apex angle α and a range of 220 to 260° for the apex angle β are more preferable.

[0035]

In addition, only light that has passed the convex conical prism or the concave conical prism and the first diaphragm 17 is incident on the transmission/scattering type display element 15, so that the directionality of the beam is properly adjusted. In addition, scattered light can be removed with high efficiency from the transmitted light that has passed the transmission/scattering type display element 15, so that a high contrast projected image is obtained.

[0036]

Also, it is possible to vary the apertures of the first diaphragm 17 that is set proximate to the second focal point position of the elliptic mirror 12 and the second diaphragm 18 that is set as the means for removing scattered light, so that for example when the periphery is dark and peripheral light has little effect on the screen, it will be possible to distinguish even dark points produced by the projector-type display apparatus, so that even if the aperture of the second diaphragm is narrowed and the passing amount of light is reduced, it will still be possible to make adjustments that achieve a high contrast, so that a bright and clear display image with a high contrast is obtained.

[0037]

Also, when the periphery is bright, light from the periphery is incident on the screen, so that dark parts of an image projected by the projector-type display apparatus appear somewhat bright, and in this case by opening the apertures of both diaphragms, the amount of projected light can be increased to make the screen brighter, so that the contrast can be increased and the image can be made clearer.

[0038]

[Embodiments]

First Embodiment

FIG. 2 shows a projector-type display apparatus 100 that is a first embodiment of the present invention. The specifications of the spherical mirror 10, the elliptic mirror 12, the prism 14, and the condensing lens 13 used in this embodiment are given below.

[0039]

The spherical mirror 10 is formed by fabricating a hemisphere with a radius of curvature R=9mm from one surface of a Pyrex (a registered trademark of Iwaki Glass Co., Ltd.) glass cylinder that has a diameter of 22mm and a length of 10mm so that the depth h=8mm, and then forming a hole with a diameter of 8mm for passing through an electrode of the lamp. In addition, an aluminum mirror with an SiO film as a protective film is coated on an inner spherical surface of the spherical mirror.

[0040]

The elliptic mirror 12 is produced by forming a cold mirror on an inner surface of Pyrex glass that has been machined so that the first focal point distance f_1=22mm, the second focal point distance f_2=105mm, and the depth H=27mm.

[0041]

Here, when the spherical mirror and the elliptic mirror have been disposed so that their reflective surfaces face one another along the optical axis and the first focal point of the elliptic mirror matches the center of curvature of the spherical mirror, the diameter D_A of a circle A that is a line of intersection between a plane perpendicular to the optical axis and the surface of the elliptic mirror at the first focal point is set at around 73mm and the diameter D_B of a circle B that is a line of intersection between a

perpendicular plane and the surface of the spherical mirror is set at around 18mm.

[0042]

The prism 14 is formed of BK7 glass with an apex angle of 114°, a diameter of 30mm and a height of 12mm, with an anti-reflection coating formed on the light incident surface and the light emission surface. The condensing lens is formed of plano-convex BK7, and a lens (the lens numbered 13A in FIG. 2) with a focal point distance f_A=200mm is used on the incident side of the display element and a lens (the lens numbered 13B in FIG. 2) with a focal point distance f_B=350mm is used on the emission side of the display element.

[0043]

The conical prism 14 and the first diaphragm 17 are set at the second focal point position of the elliptic mirror 12, and the various optical components described above are disposed as shown in FIG. 2. The first diaphragm is an iris diaphragm whose aperture diameter D_A is variable. The light that has passed through the display element is condensed by the second condensing lens 13B and the second diaphragm 18 is set at a position at which an image of the aperture of the first diaphragm 17 is formed so that the aperture of the second diaphragm 18 matches the image of the aperture of the first diaphragm 17. The light that has passed the aperture of the second diaphragm passes the projection lens 19 and is projected onto the screen. The second diaphragm 18 may be disposed away from the projection lens 19, but it is preferable to set the second diaphragm 18 at a pupil position of the projection lens.

[0044]

If the diameter of the aperture of the first diaphragm 17 is a, the diameter of the aperture of the second diaphragm 18 is b, the scattering angle Φ of the incident light of

the display element and the condensing angle δ showing the directivity of the projected light are set by the following expressions.

[0045]

[Expression 1]

$$\tan\Phi=a/f_A \quad \cdots\cdots \text{Equation (1)}$$

$$\tan\delta=b/f_B \quad \cdots\cdots \text{Equation (2)}$$

[0046]

Here, the aperture diameters a, b of the first diaphragm and the second diaphragm are simultaneously adjusted so that $\Phi=\delta$.

[0047]

A discharge emission-type metal halide lamp is used as the light source 11. The light source 11 is a DC discharge lamp with an arc emission electrode length of 3mm and a power consumption of 150W. A display part of the display element 15 is 48mm by 64mm with a 3.15 (inch) diagonal. In experiments, measurements were made with a mask with an aperture equal to the display part being disposed in place of the display element.

[0048]

With this construction, a projection lens 19 with a focal point distance of 180mm was used, an actual size image with a scale factor 1 was formed on a light scattering/transmitting screen, and the amount of projected light was measured as an image using a CCD camera. During measurement, $\Phi=\delta$ was varied in a range of 4 to 7° and each time the emission point of the lamp was moved to maximize the projected amount of light.

[0049]

For comparison purposes, the case where only the elliptic mirror 12 is used with no spherical mirror (a first comparative example) and the case where a large spherical mirror 20 is combined as shown in FIG. 9 (a second comparative example) were also measured.

[0050]

The results are shown in FIG. 3. From these results, it can be seen that compared to the conventional case where only an elliptic mirror is used, by using the spherical mirror according to the present invention, a large increase in the amount projected light was achieved, especially when $\Phi = \delta = 4$ to $5°$. An increase in the amount of projected light was also confirmed compared to the case where a conventional elliptic mirror was combined with a large spherical mirror, but by using a small spherical mirror, an equal effect or greater was obtained with a small, lightweight, and low cost design.

[0051]

In the case of a projector-type display apparatus that uses a transmission/scattering type display element, the higher the directivity of the incident light and emitted light, that is, the smaller the value of $\Phi = \delta$, the more effectively the scattered light generated by scattering display parts of the display element is removed and so is not projected onto the screen, so that a high contrast is obtained. Accordingly, from the measurement results of the above embodiment, the directivity (that is, $\Phi = \delta$ is set at a low value) of the incident light and the projected light is improved so that amount of projected light is the same as in the related art and the contrast of the projected image can be improved.

[0052]

In the present embodiment, a discharge emission-type metal halide lamp is used as the light source, but aside from such lamp, it is possible to use a xenon lamp, an electrodeless microwave discharge lamp, a filament-emission type halogen lamp, or the like.

[0053]

In particular, when an electrodeless microwave discharge lamp disclosed in SID 92 DIGEST, p.460, D. A. MacLennan et al. (Fusion System Corp.) is used, for example, it is possible to achieve a long lamp life of 10,000 hours, which is suited to use with the condensing mirror construction of the present invention. That is, with an electrodeless microwave discharge lamp, discharge element gas is sealed in a spherical glass tube such as that shown in FIG. 4 and microwaves are applied from the outside so that a non-metallic mirror may be formed directly on a hemispherical surface of the glass tube as shown in the drawing.

[0054]

Also, although a spherical mirror is disposed on a side facing the elliptic mirror along the optical axis in the present embodiment, as shown in FIG. 5 two types of spherical mirror may be disposed so as to cover both sides of the light emitting part of the lamp with the respective centers of curvature of both being inside the light emitting part. The emitted light is emitted from narrow parts where there are no spherical surface parts of the spherical mirrors and is condensed at the second focal point position by the elliptic mirror, so that a further improvement in the beam density and increase in the condensing efficiency can be expected.

[0055]

In this case, as shown in FIG. 5, a spherical mirror split in two may be mounted

on the lamp, or as shown in FIG. 6, the lamp may have a double-layer tube construction with reflective layers being formed on the surface of the outer spherical glass tube. By forming the lamp with a double-layer tube construction, the temperature of the light emitting part can be made more uniform, which can stabilize the characteristics and extend the life of the lamp.

[0056]

Any planar display element that can assume a transmitting state and a scattering state when a voltage is applied can be used as the transmission/scattering type display element used in the present invention. Specific examples of such include a dynamic scattering mode (DSM) liquid crystal display element, a liquid crystal display element that uses a compound structure of liquid crystals and resin where liquid crystals are dispersed and held inside a resin matrix, and the transmission/scattering is controlled according to whether the refractive index of the liquid crystals and the refractive index of the resin matrix match or do not match, and an element in which minute needle-like particles are dispersed in a solution and the transmission/scattering is controlled according to the applied voltage

[0057]

Out of these, a liquid crystal display element that uses a compound structure of liquid crystals and resin has a favorable optical transmission-scattering performance, can be manufactured using a similar manufacturing process to a conventional TN-type liquid crystal display element, and is easy to use since it can be driven using the same driving IC.

[0058]

For the compound liquid crystal/resin structure used as an electro-optic

functional layer of a liquid crystal display that uses a combined liquid crystal/resin structure, resin phases and liquid crystal phases are intricately formed within a space. For example, this layer is formed of liquid crystals that fill the holes in a resin matrix in which many minute holes are formed, and depending on the applied voltage, light is transmitted when the refractive index of the liquid crystals and the refractive index of the resin matrix match and is scattered when the respective refractive indexes do not match.

[0059]

More preferably, by using nematic liquid crystals with positive dielectric anisotropy and making the refractive index of the resin matrix approximately match the normal refractive index (n_0) of the liquid crystals, high transmissivity is exhibited when a voltage is applied, with parts between pixels where there are no electrodes being placed in the scattering state (so as to appear as black when projected on the screen), so that a higher contrast image is achieved even if a light blocking film is not provided between pixels.

[0060]

A liquid crystal/resin compound structure may be constructed by sealing liquid crystals inside bubbles such as microcapsules. The individual microcapsules do not need to be completely independent, and the individual bubbles of liquid crystals may be connected via narrow gaps as in a porous body. To achieve favorable electro-optic characteristics, it is preferable for the liquid crystal phases to be completely connected to compose a liquid crystal domain that is surrounded by the resin phase formed in a mesh.

[0061]

This liquid crystal/resin compound structure can be formed by mixing the liquid crystals and the material for composing the resin matrix, hardening this mixture in a solution or latex state by photo-curing, thermal curing, hardening by solvent removal, reactive curing, or the like to separate the resin matrix and place the liquid crystals in a dispersed state inside the resin matrix.

[0062]

In particular, it is preferable to use a photo-curing or thermal-curing resin as the resin since such resin can be hardened inside a sealed system, and in particular, a photo-curing resin is preferable since it can be hardened in a short time and is not affected by heat.

[0063]

More specifically, a photo-curing vinyl resin is preferably used. A photo-curing acrylic resin is illustrated, and in particular, a resin including an acrylic oligomer that undergoes polymer hardening when irradiated with light is preferable.

[0064]

As a more specific manufacturing method, cells are formed using the same type of seal material as a normal conventional TN-type liquid crystal display element, unhardened mixture of liquid crystals and a resin matrix is introduced from a fill opening, the fill opening is sealed, and then hardening is carried out by irradiation with light or by heating.

[0065]

It is also possible to supply the unhardened mixture of liquid crystals and the resin matrix onto a plate provided with electrodes, to then lay on another plate provided with electrodes and to harden the mixture by irradiation with light or the like. Also,

additives such as ceramic particles, plastic particles, glass fibers or other type of spacer for controlling the gap between the plates, a pigment, a dye, a viscosity adjusting agent, or other additive that does not adversely affect the performance of the present invention may be added to this unhardened mixture.

[0066]

When this kind of element is used, during the hardening process, by carrying out hardening by applying a sufficiently high voltage to only specified parts, it is possible to place such parts in a state that normally transmits light, so that when there is an image to be continuously displayed, an appropriate transmitting part may be formed.

[0067]

The response time of a liquid crystal display element that uses this kind of liquid crystal/resin compound structure is around 3 to 50 msec for a rise in applied voltage and around 10 to 80 msec for a fall when the voltage is removed, which makes the liquid crystal display faster than a conventional TN-type liquid crystal display element and means that the voltage-transmissivity electro-optic characteristics are also suited to driving that realizes a multilevel display. In view of the scattering performance when there is no electric field, a volume fraction ξ of liquid crystals that can operate in a liquid crystal/resin compound structure should preferably be set so that $\xi > 20\%$, with $\xi > 35\%$ being even more preferable. On the other hand if ξ is too large, the structural stability of the liquid crystal/resin compound structure deteriorates, so that $\xi < 80\%$ is preferable.

[0068]

This liquid crystal/resin compound structure is held between the plates provided with electrodes. A liquid crystal display element that uses this liquid

crystal/resin compound structure does not have favorable multiplex driving characteristics, so that when the liquid crystal display element has a large number of pixels, active elements are disposed in each pixel.

[0069]

Of course, active elements may also be disposed as necessary in an external transmission/scattering type display element. When three-terminal elements, such as TFTs (thin film transistors), are used as the active elements, a flat electrode that is shared by every pixel may be provided on the second plate provided with electrodes, but when two-terminal elements such as MIM elements or PIN diodes are used, the second plate provided with electrodes is patterned in the form of stripes.

[0070]

Also, when TFTs are used as the active elements, silicon is preferably used as the semiconductor material. In particular, polycrystalline silicon is preferable since it has low photosensitivity compared to amorphous silicon.

[0071]

Transparent electrodes are normally used as the electrodes, but in the case where a reflective liquid crystal display element is used, reflective electrodes of aluminum, silver, and the like may be used. In a projector-type display apparatus, as described above a transmissive-type liquid crystal display is normally used as a transmission/scattering type display element and an image is projected onto a screen provided separately. In this case, the display apparatus may be a front surface projection-type device (where the viewer views images from the same side of the screen as the projector-type display apparatus) or a rear surface projection-type device (where the viewer views images from a position on the opposite side of the screen to the

projector-type display apparatus)

[0072]

It is also possible to construct a reflective projector-type display apparatus that uses a reflective-type liquid crystal display element that uses reflective electrodes or has a reflective layer provide on a rear of the element, with the emitted light being guided to an incident side of the display element. The transmission/scattering type display element can be used as a transmission/scattering type display element with a flat electrode across the entire surface, as a transmission/scattering type display element with simple patterned electrodes, and also as a projector-type display apparatus or as a lighting apparatus.

[0073]

For example, if the construction of the apparatus shown in FIG. 1 is disposed so as to be embedded in a wall, ceiling, or the like, it is possible to dim the lighting at high speed without changing the color. Also, if the construction of the apparatus shown in FIG. 1 or FIG. 5 is disposed so as to be embedded in a wall, ceiling, or the like, it is possible to dim lighting at high speed without changing the color, or to dim lighting while also changing the color.

[0074]

In addition, although a single transmission/scattering type display element 15 is used in the present embodiment, it is possible to use a plurality of transmission/scattering type display elements 15 for respective colors to produce a full color display.

[0075]

It is also possible to achieve a color display by forming an RGB mosaic color

filter on each pixel of a single transmission/scattering type display element 15 and applying RGB image signals to each color pixel. In the case where transmission/scattering type display elements are provided for the respective colors, it is possible to use a construction where the light is projected after being combined using dichroic mirrors, dichroic prisms, or the like or a construction where the colored light is projected separately and is combined on the screen, but if the light is combined and then projected, only one optical axis is used, which is advantageous in applications where a small device size and portability are required.

[0076]

Second Embodiment

An example of a projector-type display apparatus 200 that uses three transmission/scattering type display elements (numbered 15B, 15G, and 15R in the drawings) for the respective colors R, G, and B is shown in FIG. 7.

[0077]

It should be noted that although the condensing lenses 13A and 13B (13BB, 13BG, 13BR) are disposed separately before and after the display element in the first embodiment and the second embodiment, it is possible to dispose a condensing lens on only the incident side or the emission side of the display element. Also, the second diaphragm 18 that functions as a scattered light removing system may be placed before or after the projection lens and may even be provided inside the projection lens.

[0078]

Third Embodiment

An example of a projector-type display apparatus 300 that uses a single reflective-type liquid crystal display element 25 in which pixel electrodes on one side of

the transmission/scattering type display element are realized by reflective electrodes is shown in FIG. 8. FIG. 8 is a plan view, while FIG. 9 is a side elevation. In this case, the incident light is inclined by an angle of 4 to 10° with respect to a normal for the reflective electrode surface of the display element, and regular reflected light that has passed the second diaphragm 18 is projected on the screen by the projection lens 19.

[0079]

By using a reflective display element, compared to a transmissive type, the light passes through the transmission/scattering liquid crystal material layer in both directions, so there is a large improvement in scattering performance at the same driving voltage. As a result, the projected image has improved contrast.

[0080]

The above arrangement also assists in miniaturization of a projector-type display apparatus. In particular, an example of a projector-type color display apparatus 400 provided with three transmission/scattering type display elements (35R, 35G, and 35B) for the respective colors R, G, and B is shown by a plan view in FIG. 10 and a side elevation in FIG. 11. By using this construction, the dichroic mirrors 41, 42 are commonly used as a color splitting system and a color combining system, so that compared to the transmissive-type projector-type display apparatus 200 shown in FIG. 7, the apparatus can be easily miniaturized.

[0081]

[Effect of the Invention]

The present invention is extremely small and lightweight but can produce a beam with a high output, high efficiency, high directivity, and high uniformity. When incorporated in a projector-type display apparatus that is one example application, it is

possible to obtain a projected image with high luminance and high contrast. The present invention can also be applied in a variety of other ways without losing the effect of the invention.

[Brief Description of the Drawings]

[FIG. 1] FIG. 1 is a block diagram showing a first example construction of a light source apparatus according to the present invention.

[FIG. 2] FIG. 2 is a block diagram showing a first example construction of a projector-type display apparatus according to the present invention.

[FIG. 3] FIG. 3 is a characteristics graph showing measurement results for projector-type display apparatuses according to a first embodiment of the present invention and the related art.

[FIG. 4] FIG. 4 is a block diagram showing a second example construction of a light source apparatus according to the present invention.

[FIG. 5] FIG. 5 is a block diagram showing a third example construction of a light source apparatus according to the present invention.

[FIG. 6] FIG. 6 is a block diagram showing a fourth example construction of a light source apparatus according to the present invention.

[FIG. 7] FIG. 7 is a block diagram showing a second example construction of a projector-type display apparatus according to the present invention.

[FIG. 8] FIG. 8 is a plan view showing a third example construction of a projector-type display apparatus according to the present invention.

[FIG. 9] FIG. 9 is a side elevation showing a third example construction of a projector-type display apparatus according to the present invention.

[FIG. 10] FIG. 10 is a plan view showing a fourth example construction of a projector-type display apparatus according to the present invention.

[FIG. 11] FIG. 11 is a side elevation showing a fourth example construction of a projector-type display apparatus according to the present invention.

[FIG. 12] FIG. 12 is a block diagram showing a first example construction of a light source apparatus according to the related art.

[FIG. 13] FIG. 13 is a block diagram showing a first example construction of a projector-type display apparatus according to the related art.

[FIG. 14] FIG. 14 is a block diagram showing a second example construction of a light source apparatus according to the related art.

[Reference Numerals]

10: SPHERICAL MIRROR

11: LIGHT SOURCE

12: ELLIPTIC MIRROR

13, 13A, 13B, 13G, 13R, 13BB, 13BG, 13BR: CONDENSING LENS

14, 14a, 14b: CONICAL PRISM

15, 15B, 15G, 15R, 25, 35B, 35G, 35R: TRANSMISSION/SCATTERING TYPE DISPLAY ELEMENT

17: FIRST DIAPHRAGM

18: SECOND DIAPHRAGM

19: PROJECTION LENS

41, 42, 41a, 42a, 41b, 42b: DICHROIC MIRROR

M1, M2: MIRROR

TRANSLATION OF DRAWINGS

FIG. 3

スクリーン光束「任意単位」- SCREEN FLUX (AT ARBITRARY POSITION)

集光角 – CONVERGING ANGLE

実施例１… FIRST EMBODIMENT (ELLIPTIC MIRROR AND SMALL SPHERICAL MIRROR)

比較例1… FIRST COMPARATIVE EXAMPLE (ELLIPTIC MIRROR)

比較例２… SECOND COMPARATIVE EXAMPLE (ELLIPTIC MIRROR AND LARGE SPHERICAL MIRROR)

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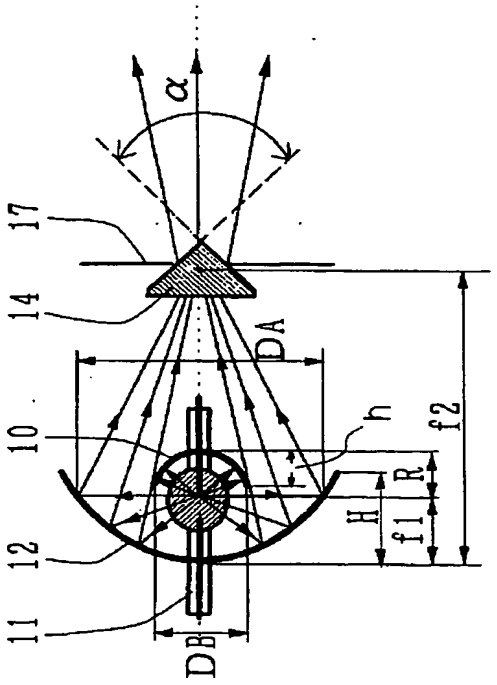
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(54)【発明の名称】　光源装置及びその応用装置

(57)【要約】
【課題】高効率、高出力、高指向性の光束を得る。
【解決手段】楕円鏡１２の第１焦点に光源１１を、第２焦点に第１の絞り１７と錐体状プリズム１４とを配置し、第１の絞り１７を通過した光を収束し出射する集光レンズを設け、楕円鏡１２と対向して小型の球面鏡１０を配置し、楕円鏡１２の第１焦点での光軸の垂直面と楕円鏡面との交線である円Ａの直径D_Aが球面鏡１０との交線である円Ｂの直径D_Bより大きい光源装置。



1

【特許請求の範囲】

【請求項１】楕円鏡（１２）の第１焦点と球面鏡（１０）の曲率中心とがほぼ一致し、その位置近傍に光源（１１）が配置され、楕円鏡（１２）の第２焦点の位置近傍に第１の開口絞り（１７）が配置され、第１の絞り（１７）を通過した光を収束せしめる集光レンズ（１３）が設けられ、集光レンズ（１３）を通過した光が出射される光源装置であって、

楕円鏡（１２）の反射面と球面鏡（１０）の反射面とが光軸に沿って向き合い、楕円鏡（１２）の反射面が球面鏡（１０）の反射面より大きい光源装置。

【請求項２】楕円鏡（１２）の第１焦点における光軸の垂直面と楕円鏡面との交線である円Ａの直径D_Aが球面鏡（１０）との交線である円Ｂの直径D_Bに比べて大きい請求項１の光源装置。

【請求項３】楕円鏡（１２）の第１焦点距離f_1と球面鏡（１０）の曲率半径Ｒとが$f_1 > R$の関係を満たす請求項１又は２の光源装置。

【請求項４】光軸上における楕円鏡（１２）の反射面の深さＨは第１焦点距離f_1及び焦点距離f_2に対して、$f_1 \leqq H \leqq (f_1 + f_2)/2$の関係を満たし、光軸上における球面鏡（１０）の反射面の深さｈは曲率半径Ｒに対して、$R/2 \leqq h \leqq R$の関係を満たす請求項１、２又は３の光源装置。

【請求項５】楕円鏡（１２）の第２焦点近傍に錐体状プリズム（１４）が設けられ、錐体状プリズム及び第１の絞り（１７）を通過した光が集光レンズ（１３）により収束される請求項１、２、３又は４の光源装置。

【請求項６】錐体状プリズム（１４）は、光の入射面又は出射面の頂角αが９０～１７５°である凸錐体状プリズム又は頂角βが１８５～２７０°の凹錐体状プリズムである請求項５の光源装置。

【請求項７】請求項１～６のいずれか１項の光源装置から出射された光が入射される透過散乱型表示素子（１５）及び、この透過散乱型表示素子（１５）を通過した光をスクリーン等に投射せしめる投射光学系とを備える投射型表示装置。

【請求項８】請求項７の投射型表示装置において、投射光学系に第２の集光レンズ（１６）と、この第２の集光レンズ（１６）のほぼ焦点位置に開口部を有する第２の絞り（１８）を配置することを特徴とする投射型表示装置。

【請求項９】請求項６、７又は８の投射型表示装置を用いる照明装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、高効率の光源装置の構造に関する。そしてそれを応用した各種の光学装置、なかでも透過散乱型表示素子を用いた投射型表示装置及びそれを用いた照明装置について具体的に開示する。

2

【０００２】

【従来の技術】図１２と図１３に特開平７－１３４２９５に記載された発明を従来例１として示す。この発明は、光源からの光の収束性を改善して光の有効利用を図った投射型表示素子である。

【０００３】図１２は、光源装置を構成する光源１１、楕円鏡１２、プリズム１４そして第１の絞り１７の配置を示す模式図である。図１３はその１つの応用例で、光源装置に、第１の集光用レンズ１３Ａ、透過散乱型表示素子１５、第２の絞り１８、第２の集光用レンズ１３Ｂ、そして投射用レンズ１９とが組み合わされて投射表示装置５００が構成された。

【０００４】この投射型表示素子においてプリズム１４は、ほぼ楕円鏡１２の第２の焦点位置に配置されていた。また、このプリズムは光軸上に対して回転対称形状を有するほぼ円錐体である。光源１１から発した光は、楕円鏡で反射収束せしめられて、プリズムに入射され、プリズムの入射面及び出射面で屈折せしめられて出射されるものであった。

【０００５】この発明では、光源から発射された光を楕円鏡を用いて集光した光束は光軸方位の配光分布の光が不足するが、プリズムにより屈折して配光分布が均一化されるとともに光束密度が向上するため、光源からの集光効率が高く、明るい表示が可能であった。

【０００６】また、楕円鏡の第２の焦点の位置近傍に第１の絞り１７を設けたことで、光源からの発散光を除去できた。つまり、光源が理想的点光源でなく有限の発光長（フィラメントの長さ等）を有するために、楕円鏡の第２の焦点近傍に到達できずに集光レンズ１３Ａに進行する光、及び楕円鏡を反射せずかつ第２の焦点位置を通過せずに透過散乱型表示素子１５に向かう光を除去でき、投射画像の明暗のコントラスト比を向上できた。

【０００７】次に、特開平７－５４１９に記載された内容を従来例２として示す。この発明は光源からの光の収束性をさらに改善して光の有効利用を図る。図１４に示すように楕円鏡１２ａの光出射側に楕円鏡の第１焦点と曲率中心をほぼ一致させて球面鏡１２ｂを配置した構成としている。ここで用いられる球面鏡はその曲率半径Ｒが楕円鏡の第１焦点距離f_1に比べて十分大きく、球面鏡の開口部の直径は楕円鏡の光出射側の開口部直径に比べて大きく楕円鏡開口部を覆うように配置されている。

【０００８】また、これらの従来例では白色光源と二種二枚の平板ダイクロイックミラーを用いた色分離合成系とＲＧＢの各波長毎に三板の透過散乱型液晶表示素子を反射型構成で用い、小型で光利用効率及び投射像のコントラスト比を向上した投射型カラー表示装置について記載されていた。

【０００９】

【発明が解決しようとする課題】本発明では、上記の従

来例ではまだ得られなかった小型、高効率、高輝度の光源装置を得ようとする。そして、他の光学系と組み合わせた投射型表示装置などにおける光学性能を改良しようとする。

【００１０】

【課題を解決するための手段】本発明ではまず高輝度かつ指向性の揃った光束を発生せしめる光源装置を提供する。球面鏡と楕円鏡とを組み合わせて小型かつ軽量かつ安価な光源装置を構成する。さらに、透過散乱型の表示素子を組み合わせて高性能の投射型表示装置及び照明装置を構成する。基本的には相対的に大きな楕円鏡と小さな球面鏡とを対向するように組み合わせ、楕円鏡面の中に球面鏡を設ける。

【００１１】具体的には、本発明は、楕円鏡１２の第１焦点と球面鏡１０の曲率中心とがほぼ一致し、その位置近傍に光源１１が配置され、楕円鏡１２の第２焦点の位置近傍に第１の開口絞り１７が配置され、第１の絞り１７を通過した光を収束せしめる集光レンズ１３が設けられ、集光レンズ１３を通過した光が出射される光源装置であって、楕円鏡１２の反射面と球面鏡１０の反射面とが光軸に沿って向き合い、楕円鏡１２の反射面が球面鏡１０の反射面より大きい光源装置を提供する。これを第１の発明と呼ぶ。反射面の相対的な大きさとはそれぞれ光軸に垂直な面に光軸に沿って投影した場合のその有効面積を指す。言い換えると、光軸垂直面における楕円鏡体の切断面である。

【００１２】また、第１の発明において、楕円鏡１２の第１焦点における光軸の垂直面と楕円鏡面との交線である円Ａの直径D_Aが球面鏡１０との交線である円Ｂの直径D_Bに比べて大きい光源装置を提供する。これを第２の発明と呼ぶ。

【００１３】また、第１又は２の発明において、楕円鏡１２の第１焦点距離f_1と球面鏡１０の曲率半径Ｒとが$f_1 > R$の関係を満たす光源装置を提供する。これを第３の発明と呼ぶ。

【００１４】また、第１、２又は３の発明において、光軸上における楕円鏡１２の反射面の深さＨは第１焦点距離f_1及び焦点距離f_2に対して、$f_1 \leqq H \leqq (f_1 + f_2)/2$　の関係を満たし、光軸上における球面鏡１０の反射面の深さｈは曲率半径Ｒに対して、$R/2 \leqq h \leqq R$の関係を満たす光源装置を提供する。これを第４の発明と呼ぶ。

【００１５】また、第１、２又は４の発明において、楕円鏡１２の第２焦点近傍に錐体状プリズム１４が設けられ、錐体状プリズム及び第１の絞り１７を通過した光が集光レンズ１３により収束される光源装置を提供する。これを第５の発明と呼ぶ。

【００１６】また、第５の発明において、錐体状プリズム１４は、光の入射面又は出射面の頂角αが９０°～１７５°である凸錐体状プリズム又は頂角βが１８５°～２７０°の凹錐体状プリズムである光源装置を提供する。これを第６の発明と呼ぶ。

【００１７】また、第１～６のいずれかの発明の光源装置から出射された光が入射される透過散乱型表示素子１５及び、この透過散乱型表示素子１５を通過した光をスクリーン等に投射せしめる投射光学系とを備える投射型表示装置を提供する。これを第７の発明と呼ぶ。

【００１８】また、第７の発明の投射型表示装置において、投射光学系に第２の集光レンズ１６と、この第２の集光レンズ１６のほぼ焦点位置に開口部を有する第２の絞り１８を配置することを特徴とする投射型表示装置を提供する。これを第８の発明と呼ぶ。

【００１９】また、第７又は８の発明において、透過散乱型表示素子１５は、電極付き基板間に正の誘電異方性のネマチック液晶が樹脂マトリックス中に分散保持された液晶樹脂複合体を有し、かつ樹脂マトリックスの屈折率が用いられる液晶の常光屈折率（n_0）と一致せしめられた透過散乱型表示素子１５である投射型表示装置を提供する。これを第９の発明と呼ぶ。

【００２０】また、第７、８又は９の発明の投射型表示装置を用いる照明装置を提供する。

【００２１】

【発明の実施の形態】図１を参照して説明する。基本的な配置構成は、上述した従来例とほぼ同様である。しかし、本発明では楕円鏡と球面鏡とを構成要素とする光源装置の配置関係に最も特徴がある。そして、均一な配光分布を持った強力な光束を得る点に特徴がある。

【００２２】本発明の光源装置は、光源１１と楕円鏡１２と球面鏡１０と第１の開口絞りと図示を省略した集光レンズとからなり、楕円鏡１２の形状は第１焦点距離f_1、第２焦点距離f_2、深さＨによって規定され、球面鏡１０の形状は曲率半径Ｒ及び深さｈによって規定される。

【００２３】楕円鏡１２の第１焦点と球面鏡１０の曲率中心とがほぼ一致し、その位置近傍に光源１１が配置され、楕円鏡１２の第２焦点の位置近傍に第１の絞り１７がそれぞれ配置され、楕円鏡１２と球面鏡１０の反射面が光軸に沿って向き合い、楕円鏡１２の第１焦点における光軸の垂直面と楕円鏡面との交線である円Ａの直径D_Aが球面鏡１０との交線である円Ｂの直径D_Bに比べて大きい。

【００２４】楕円鏡１２の第１焦点距離f_1と球面鏡１０の曲率半径Ｒとの大小関係は、$f_1 > R$であることが好ましい。また、光軸上における楕円鏡１２の反射面の深さＨは第１焦点距離f_1及び焦点距離f_2に対して、$f_1 \leqq H \leqq (f_1 + f_2)/2$　の関係を満たし、光軸上における球面鏡１０の反射面の深さｈは曲率半径Ｒに対して、$R/2 \leqq h \leqq R$の関係を満たすことが好ましい。

【００２５】また、楕円鏡１２の第２焦点近傍に錐体状

プリズム１４が設けられ、プリズム及び第１の絞り１７を通過した光が集光レンズ１３により収束されることが好ましい。また、錐体状プリズム１４は、光の入射面又は出射面の頂角αが９０～１７５°である凸錐体状プリズム又は頂角βが１８５～２７０°の凹錐体状プリズムであることが好ましい。

【００２６】球面鏡１０は耐熱性ガラスを半球形状に成形し、その内表面にアルミニウム等の可視光反射率の高い金属膜あるいは光屈折率誘電体TiO_2と低屈折率誘電体SiO_2を交互に積層し可視光を反射し赤外光を透過するコールドミラーをコーティングして得られる。また、金属板を半球形状に成形加工し、その内表面に可視光反射率の高い金属膜をコーティングしてもよい。この場合、表面の面精度はガラスの場合に比べ劣るが、耐熱性に優れ安価である。

【００２７】また、光源の発光部を形成するガラスバルブ全体を球形のガラスバルブで覆い二重管構造とし、その球形のガラスバルブの一部に反射膜を成膜してもよい。このような二重管構成とすることにより発光部の温度が安定し特性安定・長寿命化に有利である。

【００２８】

【作用】本発明では、光源１１からの放出光のうち球面鏡１０によって反射された光を光源の発光部側に戻しさらに楕円鏡１２によって反射せしめて楕円鏡の第２焦点へと集光するため、結果的に配光分布角度が狭まり光束密度が大きく向上する。

【００２９】さらに、楕円鏡の第２焦点位置に配置された錐体状プリズム１４で屈折後出射した光の光束密度も向上し、光利用効率が上昇する。このような作用は、図１４に示した楕円鏡１２と大型球面鏡２０とを組み合わせた複合鏡において既に確認されているが、従来の球面鏡２０はその外径が楕円鏡１２の外径よりも大きかった。本発明の小型の球面鏡１０を用いた構成とすることにより、光源装置の容積の小型化が達成され、コストダウン及び軽量化に効果的である。

【００３０】さらに、楕円鏡１２の第２の焦点位置に、凸型又は凹型の錐体状プリズム１４を配置している。そして、これらの錐体状プリズムの前後に、錐体状プリズムの有効面以外に到達した光が集光レンズ１３に届かないように、錐体状プリズムの有効面に対応した開口を有する第１の絞り１７を設置することが好ましい。

【００３１】実際には、錐体状プリズム１４を保持するホルダーが、絞りの機能を果たすことになる。円形や、正方形や、楕円形や、長方形などのように、透過散乱型表示素子１５の光学的形状に合った開口部を有する絞り１７が望ましい。

【００３２】これにより、有限長の光源１１と球面鏡１０及び楕円鏡１２から進行し、第２焦点位置近傍に集光されない光成分を除去し、光束を揃えることができ、透過散乱型表示素子１５が散乱状態のときスクリーンに到達する不要な光を減少させ、コントラスト比を向上させることができる。

【００３３】特に、透過散乱型表示素子１５とスクリーンとの間に、散乱光を除去する手段、具体的には第２の絞り１８を設けておくとこの効果は大きい。そして、球面鏡１０と楕円鏡１２の複合鏡を用いた場合に生じる第２焦点位置での光軸のなす角度の小さな光成分の不足に起因した透過散乱型表示素子１５の面内光強度分布の不均一性が、光源及び複合鏡の形状に応じて頂角αが９０～１７５°の凸錐体状プリズム又は頂角βが１８５～２７０°の凹錐体状プリズムを使用することにより、大きく改善され均一化される。

【００３４】光の使用効率及び投射スクリーン上での輝度分布の点で、頂角αは１００～１４０°、頂角βは２２０～２６０°の範囲がより好ましい。

【００３５】さらに、凸錐体状プリズム又は凹錐体状プリズムと第１の絞り１７を通過した光のみが透過散乱型表示素子１５に入射するため光束の指向性がよく揃うことになる。そして、透過散乱型表示素子１５を通過した透過光から高い効率で散乱光を除去でき、高コントラスト比の投射画像が得られる。

【００３６】また、楕円鏡１２の第２の焦点位置近傍に設置された第１の絞り１７と散乱光を除去する手段として設置された第２の絞り１８との開口度を可変とし、例えば、周囲が暗い際には、周囲からの光によるスクリーンへの影響は少なく、投射型表示装置による暗い点も判別できるので、２つの絞りを絞りこんで通過光量は減っても、コントラスト比は高くなるように調整することもでき、コントラスト比が高く見やすい明るさの表示画像が得られる。

【００３７】また、逆に周囲が明るい際には、周囲からの光がスクリーンに写り込むため、投射型表示装置による投射像の暗部が、ある程度明るく見えてしまうため、この際には２つの絞りを開けて、投射光量を上げ、スクリーンを明るくすることにより、コントラスト比を高くでき、より見やすくできる。

【００３８】

【実施例】

（実施例１）図２に、本発明の第１の実施例である投射型表示装置１００を示す。本実施例で用いられた、球面鏡１０、楕円鏡１２、プリズム１４、集光レンズ１３の仕様を以下に記す。

【００３９】球面鏡１０は直径２２ｍｍ長さ１０ｍｍの円筒形パイレックスガラス（岩城硝子社　商品名）の片面から曲率半径Ｒ＝９ｍｍの半球形状を深さｈ＝８ｍｍとなるように加工し、さらにランプの電極を通すため中心に直径８ｍｍの穴を形成した。さらに、内面の球面にＳｉＯ膜を保護膜としたアルミニウムミラーを成膜した。

【００４０】楕円鏡１２は第１焦点距離f_1＝２２ｍ

m、第２焦点距離f_2＝１０５mm、深さH＝２７mmの形状に加工されてパイレックスガラスの内面にコールドミラーが形成された。

【００４１】ここで、楕円鏡の第１焦点と球面鏡の曲率中心を一致させ、楕円鏡と球面鏡の反射面が光軸に沿って向き合うように配置したとき、楕円鏡の第１焦点における光軸の垂直面と楕円鏡面との交線である円Ａの直径D_Aは約７３mm、球面鏡との交線である円Ｂの直径D_Bは約１８mmとした。

【００４２】プリズム１４は、ＢＫ７ガラスを頂角１１４°、直径３０mm、高さ１２mmの円錐体形状で、光入射面及び出射面に反射防止膜が形成された。集光レンズは平凸形状のＢＫ７であり、その焦点距離f_A＝２００mmのレンズ（図面中の符号１３Ａ）を表示素子入射側に用い、焦点距離f_B＝３５０mmのレンズ（図面中の符号１３Ｂ）を表示素子出射側に用いた。

【００４３】楕円鏡１２の第２焦点位置に錐体状プリズム１４と第１の絞り１７を設置し、上記の各光学部品を図２のように配置した。第１の絞りはその開口直径D_Aが可変となる虹彩絞りとした。また、表示素子透過光がレンズ１３Ｂによって集光され、第１の絞り１７の開口部の像が結像される位置に第２の絞り１８をその開口部が第１の絞り１７の開口部の像と一致するように設置した。この第２の絞りの開口部を透過した光が投射レンズ１９を通してスクリーン上に投射される。第２の絞り１８は投射レンズ１９と分離して配置してもよいが投射レンズの瞳位置に配置されることが好ましい。

【００４４】第１の絞り１７の開口部直径をａ、第２の絞り１８の開口部直径をｂとすると、表示素子入射光の分散角Φと投射光の指向性を示す集光角δは次式で規定される。

【００４５】

【数１】$\tan\Phi = a / f_A$ ……式（１）

$\tan\delta = b / f_B$ ……式（２）

【００４６】ここで、Φ＝δとなるように第１の開口絞りと第２の開口絞りの開口径ａ、ｂを同時に調整した。

【００４７】光源１１としては、放電発光型のメタルハライドランプを用いた。その消費電力は１５０Wでアーク発光電極長が３mmのＤＣ放電ランプである。表示素子１５は表示部形状が４８mm×６４mmで対角長が３．１５サイズ（インチ）とした。実験では、表示素子を配置する代わりに開口部が表示部と同じマスクを配置して測定した。

【００４８】このような構成で、焦点距離１８０mmの投射レンズ１９を用い倍率１の等倍投射像を光拡散透過スクリーンに結像し、その投射光量をＣＣＤカメラで画像計測した。測定はΦ＝δを４～７°に変化させ、その都度投射光量が最大となるようランプの発光点を移動して行った。

【００４９】また、比較のため球面鏡を用いない楕円鏡１２のみの場合（比較例１）及び図９のように大型の球面鏡２０を組み合わせて用いた場合（比較例２）についても同様にして測定した。

【００５０】その結果を図３に示す。これより、本発明の球面鏡を用いることにより従来の楕円鏡のみを用いた場合に比べ、特にΦ＝δ＝４～５°において大幅な投射光量の増加が達成された。また、従来の楕円鏡と大型の球面鏡を組み合わせた場合と比較しても投射光量の増加が確認され、小型の球面鏡を用いて小型・軽量・低コストで同等以上の効果が得られた。

【００５１】透過散乱型表示素子を用いた投射型表示装置の場合、入射光及び投射光の指向性が高い、すなわちΦ＝δが小さな値ほど表示素子の散乱表示部によって生成される散乱光が有効に排除されスクリーン上に投射されないため、高いコントラスト比が得られる。したがって、本実施例の測定結果から、投射光量が従来と同じになるように入射光及び投射光の指向性を向上し（すなわちΦ＝δを小さな値とし）投射像のコントラスト比を向上できたことにもなる。

【００５２】本実施例では光源として放電発光型のメタルハライドランプを用いたが、それ以外に、キセノンランプや無電極マイクロ波放電ランプ及びフィラメント発光型のハロゲンランプ等もよい。

【００５３】特に、例えば SID 92 DIGEST, p. 460, D. A. MacLennan et al. (Fusion SystemCorp.)に記載されている無電極マイクロ波放電ランプを用いた場合、１００００時間のランプ長寿命が実現できるが、本発明の集光鏡構成との組み合わせが適している。すなわち、無電極マイクロ波放電ランプは図４に示すような球形のガラス管球に放電元素ガスを封入し外部からマイクロ波を印加するため、図示されるようにガラス管球の半球面に非金属のミラーを直接形成すればよい。

【００５４】また、本実施例では光軸に沿って楕円鏡と向かい合う側に球面鏡を配置しているが、図５に示すようにランプの発光部を両側から覆いいずれの曲率中心も発光部内にあるように２種の球面鏡を配置し、出射光は球面鏡の球面部のない狭い部分から出射されるようにし、その出射光を楕円鏡で第２焦点位置に集光することにより、さらに光束密度が向上し集光効率の増加が期待できる。

【００５５】この場合、図５に示すように２種の分離した球面鏡をランプに装着してもよいが、図６のようにランプを二重管構造として外周の球面ガラス管球の表面に反射層を形成してもよい。ランプを二重管構造とすることにより、発光部の温度が均一化され特性安定・寿命改善に繋がる。

【００５６】本発明に用いる透過散乱型の表示素子は、電圧の印加状態により、透過状態と散乱状態とをとりうる平面型の表示素子であれば使用できる。具体的には、ＤＳＭ（動的散乱モード）の液晶表示素子、液晶が樹脂

マトリックス中に分散保持され、その液晶の屈折率と樹脂マトリックスの屈折率との一致／不一致により透過散乱を制御する液晶／樹脂複合体を用いた液晶表示素子、微細な針状粒子を溶液に分散さておき、電圧の印加状態により透過散乱を制御する素子等がある。

【００５７】なかでも、液晶／樹脂複合体を用いた液晶表示素子は光学的な透過－散乱性能がよく、従来のＴＮ型液晶表示素子と類似の製造プロセスで製造でき、同じ駆動用ＩＣを用いて駆動可能なため、使用しやすい。

【００５８】液晶／樹脂複合体を用いた液晶表示素子の電気光学機能層として用いられる液晶／樹脂複合体は、樹脂相と液晶相とが空間内に複雑に形成される。例えば、細かな孔が多数形成された樹脂マトリックスの孔の部分に充填された液晶とからなり、電圧の印加状態により、液晶の屈折率と樹脂マトリックスの屈折率が一致した時に光が透過し、一致しない時に散乱される。

【００５９】より好ましくは、誘電異方性が正のネマチック液晶を用い樹脂マトリックスの屈折率が使用する液晶の常光屈折率（n_o）とほぼ一致するようにされることにより、電圧を印加した時に高い透過性を示すこと、及び、電極のない画素間の部分が散乱状態になっている（スクリーンに投射した際に黒くなる）ため、画素間に遮光膜を設けなくても投射画像のコントラスト比が高くなるので好ましい。

【００６０】液晶／樹脂複合体は、マイクロカプセルのような液泡内に液晶が封じ込められたような構造であってもよく、個々のマイクロカプセルが完全に独立していなくてもよく、多孔質体のように個々の液晶の液泡が細隙を介して連通していてもよい。良好な電気光学的性能を得るには液晶相が完全に連通し、網目状に形成された樹脂相に囲まれて液晶ドメインが構成されることが好ましい。

【００６１】この液晶／樹脂複合体は、液晶と樹脂マトリックスを構成する材料とを混ぜ合わせて溶液状又はラテックス状にしておいて、これを光硬化、熱硬化、溶媒除去による硬化、反応硬化等させて樹脂マトリックスを分離し、樹脂マトリックス中に液晶が分散した状態をとるようにして形成できる。

【００６２】特に、使用する樹脂として、光硬化又は熱硬化タイプにすることにより、密閉系内で硬化できるため好ましく、とりわけ、光硬化タイプの樹脂が、熱による影響を受けなく、短時間で硬化させることができ好ましい。

【００６３】より具体的には、光硬化ビニル系樹脂の使用が好ましく、光硬化性アクリル系樹脂が例示され、特に、光照射によって重合硬化するアクリルオリゴマーを含有するものが好ましい。

【００６４】具体的な製法としては、従来の通常のＴＮ型液晶表示素子と同様にシール材を用いてセルを形成し、注入口から未硬化の液晶と、樹脂マトリックスとの混合物を注入し、注入口を封止して後に、光照射をするか加熱して硬化させることもできる。

【００６５】また、電極付基板上に液晶と樹脂マトリックスとの未硬化混合物を供給し、その後、もう一枚の電極付基板を重ねて、光照射等により硬化させることもできる。この未硬化混合物に、基板間隙制御用のセラミック粒子、プラスチック粒子、ガラス繊維等のスペーサー、顔料、色素、粘度調整剤、その他本発明の性能に悪影響を与えない添加剤を添加してもよい。

【００６６】このような素子の場合、この硬化工程の際に特定の部分のみに十分高い電圧を印加した状態で硬化させることにより、その部分を常に光透過状態にすることができるので、固定表示したいものがある場合には、そのような常透過部分を形成してもよい。

【００６７】このような液晶／樹脂複合体を使用した液晶表示素子の応答時間は、電圧印加の立ち上りが３～５０ｍｓｅｃ程度、電圧除去の立ち下がり１０～８０ｍｓｅｃ程度であり、従来のＴＮ型液晶表示素子よりも速く、その電圧－透過率の電気光学特性も階調表示のための駆動に好適である。液晶樹脂複合体中の動作可能な液晶の体積分率ξは、無電界時の散乱性の点から$\xi > 20\%$が好ましく、$\xi > 35\%$がより好ましい。一方ξがあまり大きくなると、液晶／樹脂複合体の構造安定性が悪くなるため、$\xi < 80\%$が好ましい。

【００６８】このような液晶／樹脂複合体を電極付基板で挟持して用いる。この液晶／樹脂複合体を用いた液晶表示素子は、マルチプレックス駆動特性はよくないので、画素数の多い液晶表示素子とする場合には、各画素に能動素子を配置する。

【００６９】もちろん、外の透過散乱型表示素子の場合にも、必要に応じて能動素子を配置する。この能動素子としてＴＦＴ（薄膜トランジスタ）等の３端子素子を使用する場合、他方の電極付基板は全画素共通のベタ電極を設ければよいが、ＭＩＭ素子、ＰＩＮダイオード等の２端子素子を用いる場合には、他方の電極付基板はストライプ状のパターニングをされる。

【００７０】また、能動素子として、ＴＦＴを用いる場合には、半導体材料としてはシリコンが好適である。特に多結晶シリコンは、非結晶シリコンに比べて感光性が少ないため好ましい。

【００７１】また、電極は通常は透明電極とされるが、反射型の液晶表示素子として使用する場合には、アルミニウム、銀等の反射電極としてもよい。投射型表示装置は、通常は前述のように透過散乱型表示素子を透過型として使用し、別置したスクリーンに投射するようにされる。この場合、前面投射型（観察者が投射型表示装置側に位置して見る）であっても、背面投射型（観察者が投射型表示装置と反対側に位置して見る）であってもよい。

【００７２】また、反射電極を用いた又は素子の裏側に

反射層を設けた反射型の液晶表示素子を用い、出射光を入射側に導き出して投射する反射型の投射型表示装置とすることもできる。この透過散乱型表示素子を全面ベタ電極の透過散乱型表示素子としたり、簡単な電極パターニングをした透過散乱型表示素子として、さらに投射型表示装置として、又はこれを照明装置として使用できる。

【００７３】例えば、図１の装置自体をそのような構成とし、壁、天井等に埋め込んで配置しておくことにより、高速で色を変化させずに調光できる。また、図１又は図５の装置自体をそのような構成とし、壁、天井等に埋め込んで配置しておくことにより、高速で色を変化させずに調光したり、又は、色を変化させつつ調光したりできる。

【００７４】また、本実施例では、１個の透過散乱型表示素子１５としているが、各色毎に複数個の透過散乱型表示素子１５を用いフルカラー表示を行うこともできる。

【００７５】また、１個の透過散乱型表示素子１５の画素毎にＲＧＢのモザイク・カラーフィルタを形成し、各色画素にＲＧＢの画像信号を印加してカラー画像としてもよい。複数の透過散乱型の表示素子を各色毎に設けた場合には、ダイクロイックミラーやダイクロイックプリズム等で合成してから投射するように構成してもよいし、個々に投射してスクリーン上で合成されるようにしてもよいが、合成してから投射する方が光軸が一本になるので、小型で携帯を必要とする用途においては有利である。

【００７６】（実施例２）ＲＧＢ各色毎に３個の透過散乱型の表示素子（図中の１５Ｂ、１５Ｇ、１５Ｒ）を用いた場合の投射型表示装置２００の例を図８に示す。

【００７７】なお、実施例１及び実施例２では表示素子の前後に集光レンズ１３Ａと１３Ｂ（１３ＢＢ、１３ＢＧ、１３ＢＲ）を分離して配置したが、表示素子の光入射側のみ又は表示素子の光出射側のみでもよい。また、散乱光除去形として機能する第２の絞り１８も投射レンズの前側・後ろ側でもよく投射レンズ内部でもよい。

【００７８】（実施例３）透過散乱型表示素子の片側の画素電極を反射電極とした反射型の液晶表示素子２５を１個用いる場合の投写型表示装置３００の例を図８に示す。図８は平面図、図９は側面図である。この場合、入射光は表示素子の反射電極面の垂線に対して４～１０°程度傾けて入射させ、第２の開口絞り１８を通過する正規反射光を投射レンズによりスクリーンへ投射する。

【００７９】反射型表示素子とすることにより透過型に比べ透過散乱液晶材料層を往復するため、同じ駆動電圧で散乱能が飛躍的に向上する。その結果、投射像のコントラスト比が向上する。

【００８０】また、投射型表示装置の小型化に繋がる。特に、３個の透過散乱型表示素子（図中の３５Ｂ、３５Ｇ、３５Ｒ）をＲＧＢ各色毎に設けた投射型カラー表示装置４００の場合の例を図１０に平面図、図１１に側面図を示す。このような構成とすることによりダイクロイックミラー４１、４２を色分離系及び色合成系として共用できるため、図７の透過型の投射型表示装置２００に比べ小型化しやすい。

【００８１】

【発明の効果】本発明によって、超小型軽量であっても、高出力、高効率、高指向性、高均一性の光束を発生せしめうるようになった。そして、その応用例として投射型表示装置に組み込むことで高コントラスト、高輝度の投射画像が得られるようになった。本発明は、このほか、本発明の効果を損しない範囲内で種々応用できる。

【図面の簡単な説明】

【図１】本発明の光源装置の第１の構成例を示すブロック図。

【図２】本発明の投射型表示装置の第１の構成例を示すブロック図。

【図３】実施例１における本発明と従来技術の投射型表示装置の測定結果を示す特性図。

【図４】本発明の光源装置の第２の構成例を示すブロック図。

【図５】本発明の光源装置の第３の構成例を示すブロック図。

【図６】本発明の光源装置の第４の構成例を示すブロック図。

【図７】本発明の投射型表示装置の第２の構成例を示すブロック図。

【図８】本発明の投射型表示装置の第３の構成例の平面図。

【図９】本発明の投射型表示装置の第３の構成例の側面図。

【図１０】本発明の投射型表示装置の第４の構成例の平面図。

【図１１】本発明の投射型表示装置の第４の構成例の側面図。

【図１２】従来例の光源装置の第１の構成例を示すブロック図。

【図１３】従来例の投射型表示装置の第１の構成例を示すブロック図。

【図１４】従来例の光源装置の第２の構成例を示すブロック図。

【符号の説明】

１０：球面鏡

１１：光源

１２：楕円鏡

１３、１３Ａ、１３Ｂ、１３Ｇ、１３Ｒ、１３ＢＢ、１３ＢＧ、１３ＢＲ：集光レンズ

１４、１４ａ、１４ｂ：錐体状プリズム

１５、１５Ｂ、１５Ｇ、１５Ｒ、２５、３５Ｂ、３５

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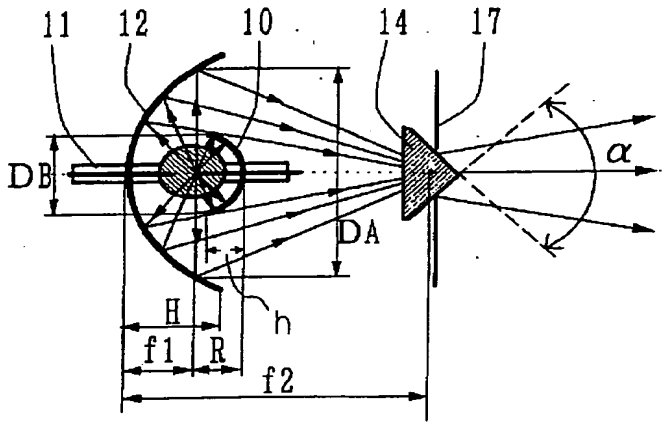
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G、３５Ｒ：透過散乱型表示素子
１７：第１の開口絞り
１８：第２の開口絞り
１９：投射用レンズ

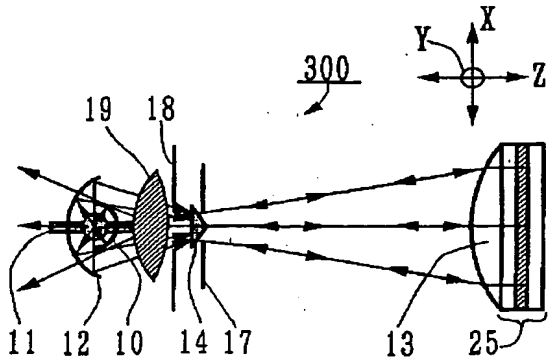
14

４１、４２、４１ａ、４２ａ、４１ｂ、４２ｂ：ダイクロイックミラー
Ｍ１、Ｍ２：ミラー

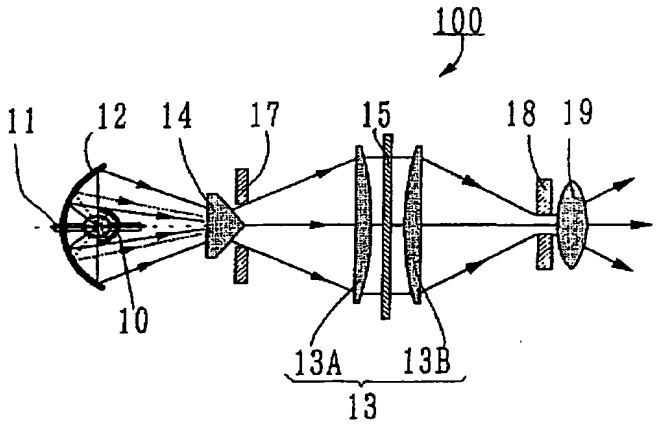
【図１】



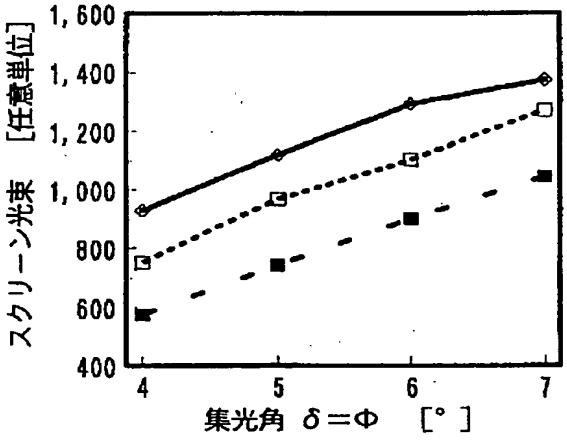
【図８】



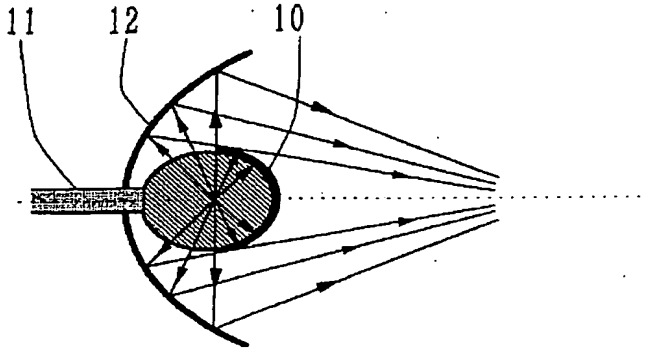
【図２】



【図３】

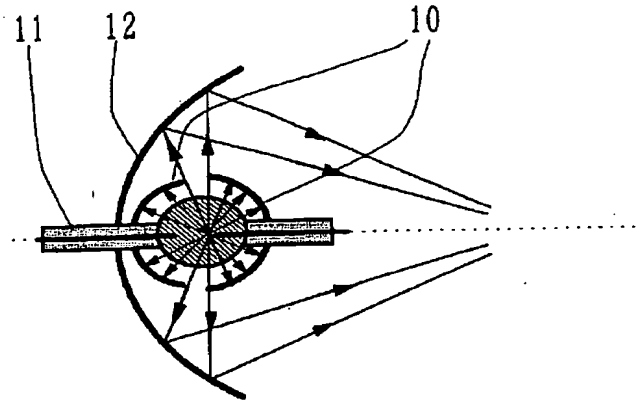


【図４】

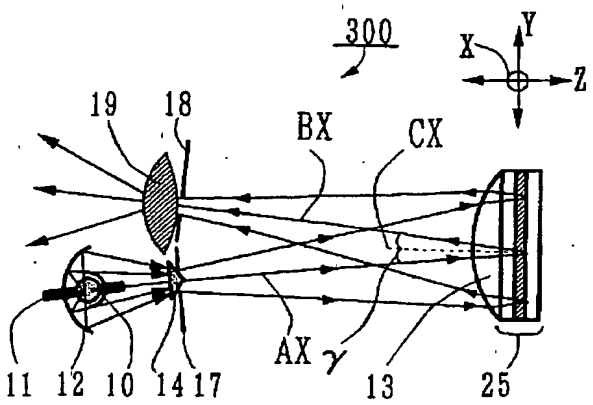


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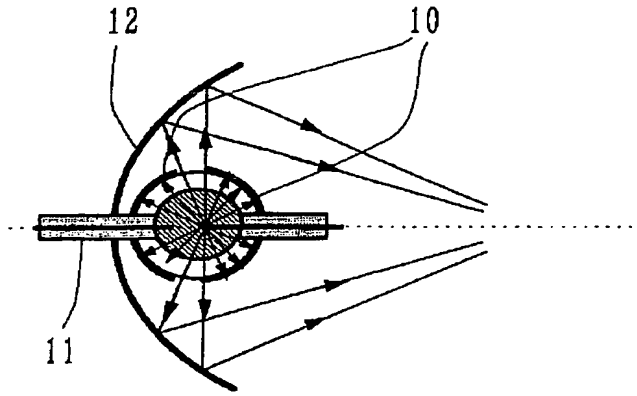
【図５】



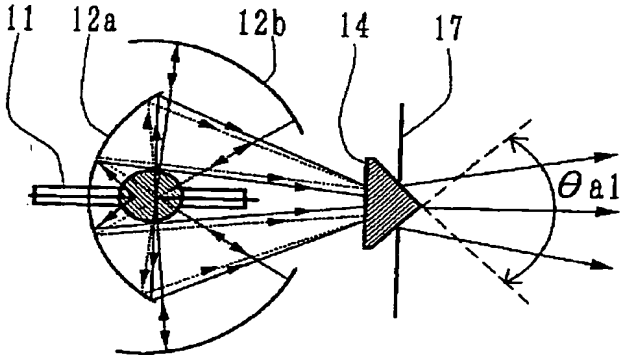
【図９】



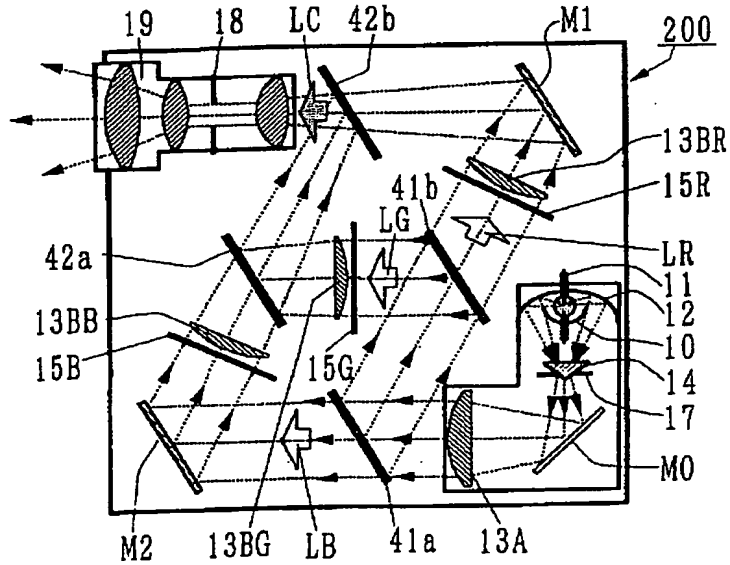
【図６】



【図１４】

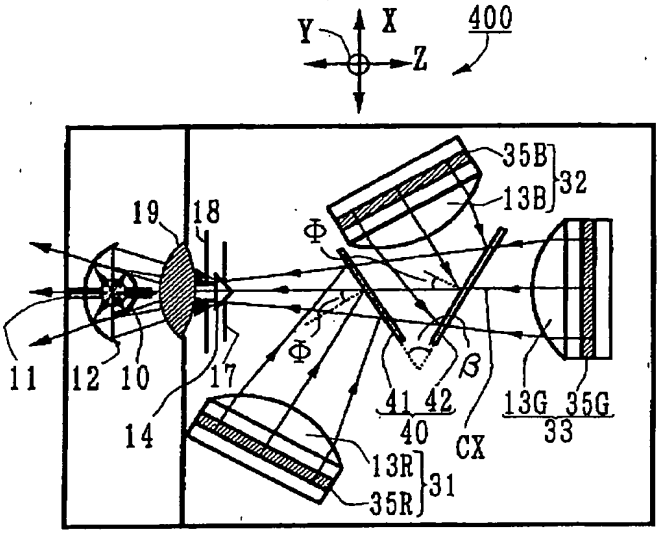


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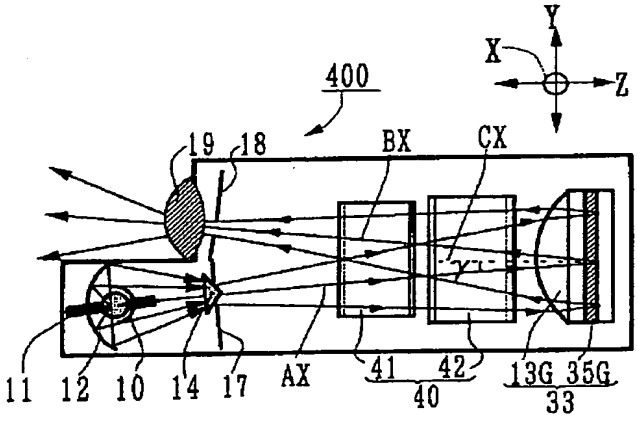


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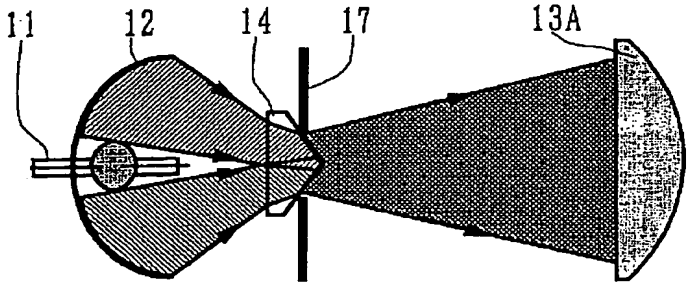
【図１０】



【図１１】



【図１２】



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【図１３】

